

WHAT IS CLAIMED IS:

1. A scheduler for a server comprising:

a first level generator associated with groups of connections; and

a second level generator associated with connections corresponding to the groups of connections, said first level generator identifying which connections in the second level generator corresponds to a group in the first level generator that are to be considered for service, said second level generator identifies the connections corresponding to the group to receive service from the server, said second level generator in connection with said first level generator.

2. A scheduler as described in Claim 1 including a first level filter mechanism which filters out inactive groups of connections, said first level filter mechanism connected to the first level generator and the second level generator.

3. A scheduler as described in Claim 2 including a second level filter mechanism which filters out inactive connections, said second level filter mechanism connected to the second level generator.

4. A scheduler as described in Claim 3 including a zero level generator associated with supergroups corresponding with groups, said zero level generator in connection with the first level generator, said zero level generator identifying which groups in the first level generator correspond to a supergroup in the zero level generator that are considered for service.

5. A scheduler as described in Claim 4 including a zero level filter mechanism which filters out inactive supergroups, said zero level filter mechanism connected to the zero level generator and the first level generator.

6. A scheduler as described in Claim 5 wherein the zero level generator includes a zero level bitmap generator which generates a zero level schedule bitmap which indicates the supergroup to be scheduled for service, the first level generator includes a first level bitmap generator which indicates the group to be scheduled for service, and the second level generator includes a second level bitmap generator which generates a second level schedule bitmap which indicates the connections to be scheduled for service.

7. A scheduler as described in Claim 6 wherein the zero level, first level and second level filter mechanism includes a zero level filter encoder, first level filter encoder and second level filter encoder, respectively, which filters out inactive supergroups from the zero level schedule bitmap and encodes the zero level schedule bitmap with inactive supergroups removed, which filters out inactive groups from the first level schedule bitmap and encodes the first level schedule bitmap with inactive groups removed, and which filters out inactive connections from the second level schedule bitmap and encodes the second level schedule bitmap with inactive connections removed, respectively.

8. A scheduler as described in Claim 7 including an interface which maintains a zero level active bitmap, a first level active bitmap and a second level active bitmap having only active connections corresponding to the zero level schedule bitmap, first level schedule bitmap and second level schedule bitmap, respectively.

9. A scheduler as described in Claim 8 wherein the zero level filter encoder reads the zero level schedule bitmap and ANDS it with the zero level active bitmap to filter out inactive supergroups, the first level filter encoder reads the first level schedule bitmap and ANDS it with the first level active bitmap to filter out inactive groups, and the second level filter encoder reads the second level schedule bitmap and ANDS it with the second level active bitmap to filter out inactive supergroups.

10. A scheduler as described in Claim 9 wherein the zero level bitmap generator, first level bitmap generator and second level bitmap generator dynamically generates bits for each supergroup, group and connection, respectively.

11. The scheduler as described in Claim 10 wherein the zero level bitmap generator includes a counter for each supergroup which is decremented as a function of an intercell interval, wherein the intercell interval is the time it takes for the server to service a cell, the first level bitmap generator includes a counter for each group which is decremented as a function of the intercell interval, and the second level bitmap generator includes a counter for each connection which is decremented as a function of the intercell interval.

12. A scheduler as described in Claim 11 wherein the zero level bitmap generator sets a bit for a supergroup whose counter decrements to zero, the first level bitmap generator sets a bit for a group whose counter decrements to zero, and the second level bitmap generator sets a bit for a connection whose counter decrements to zero.

13. A scheduler as described in Claim 12 wherein the zero level bitmap generator, first level bitmap generator and

second level bitmap generator each include a rate limiting counter associated with each counter, wherein the bit for the supergroup, group or connection, respectively, is set whenever both the counter and the corresponding rate limiting counter decrements to zero.

14. A scheduler as described in Claim 13 wherein the zero level bitmap generator, first level bitmap generator and second level bitmap generator each generate a guaranteed rate bitmap for supergroups, groups and connections, respectively, which receive service before any other supergroups, groups or connections, respectively, in the respective schedule bitmaps.

15. A scheduler as described in Claim 14 wherein the zero level bitmap generator, first level bitmap generator and second level bitmap generator proportionately reduce the service to each supergroup, group and connection, respectively, when overbooking occurs and when total bandwidth is less than the line rate.

16. A method for scheduling service of a server comprising the steps of:

identifying a group of connections with a first level generator to receive service from the server; and

identifying connections corresponding with the group of connections with a second level generator to receive service from the server.

17. A method as described in Claim 16 including after the identifying the group of connections step, there is the step of filtering out inactive groups of connections in regard to the first level generator.

18. A method as described in Claim 17 including after the identifying the connections step, there is the step of filtering out inactive connections in regard to the second level generator.

19. A method as described in Claim 18 including before the step of identifying the group of connections, there is the step of identifying groups in the first level generator corresponding to a supergroup and a zero level generator.

20. A method as described in Claim 19 including after the identifying groups step, there is the step of filtering out inactive supergroups of connections in regard to the zero level generator.

21. A method as described in Claim 20 wherein the filtering out the inactive supergroups step includes the step of ANDing a zero level schedule bitmap of the zero level bitmap generator with a zero level active bitmap of an interface to filter out inactive supergroups.

22. A method as described in Claim 21 wherein the filtering out the inactive groups step includes the step of ANDing a first level schedule bitmap of the first level bitmap generator with a first level active bitmap of an interface to filter out inactive groups.

23. A method as described in Claim 22 wherein the filtering out the inactive connections step includes the step of ANDing a second level schedule bitmap of the second level bitmap generator with a second level active bitmap of an interface to filter out inactive connections.

24. A method as described in Claim 23 wherein the identifying the groups of connections includes the step of generating dynamically the zero level schedule bitmap, the identifying the group step includes the step of generating dynamically the first level schedule bitmap, and the identifying the connections step includes the step of generating dynamically the second level generator schedule bitmap.

25. A method as described in Claim 24 wherein the step of generating the zero level schedule bitmap includes the step of decrementing a counter for each supergroup every intercell interval; the step of generating the first level schedule bitmap includes the step of decrementing a counter for each group every intercell interval; the step of generating the second level schedule bitmap includes the step of decrementing a counter for each connection every intercell interval.

26. An apparatus for serving connections comprising:

a server;

a memory in which data of the connections is stored, said memory connected to the server; and

a hierarchical scheduler which schedules when the data of the connections in the memory is to receive service from the server, said scheduler connected to said server and said memory.

27. An apparatus for serving connections comprising:

a server;

a memory in which cells of the connections are stored, said memory connected to the server; and

a scheduler which schedules when the cells of the connections in the memory are to receive service from the server based on intercell intervals, wherein an intercell interval is how long the server takes to service a cell, said scheduler connected to said server and said memory.

28. An apparatus as described in Claim 27 wherein the intercell intervals are inversely proportional to bandwidth allocated to a connection.

29. An apparatus as described in Claim 27 wherein spacing at intercell intervals of cells is performed by either statically storing a set of schedule bitmaps or by dynamically generating the schedule bitmap specifying which connections are to be served.

30. An apparatus as described in Claim 12 wherein each counter at each level has a different number of bits.

31. An apparatus as described in Claim 8 wherein each active bitmap has a bit which is set to 1 when an associated connection is active and is set to 0 when an associated connection is inactive.

32. An apparatus as described in Claim 1 wherein connections arise from entities, and including multiple counters associated with each entity which have multiple bits, including multiple schedule bitmaps associated with each entity that are used to schedule connections from the corresponding entity at different priorities or a combination of priorities.

33. An apparatus for serving connections comprising:

a server;

a memory in which cells of the connections are stored, said memory connected to the server; and

a scheduler having a schedule bitmap which schedules when cells of the connections in the memory are to receive service from the server, said scheduler connected to said server.

34. An apparatus for serving connections comprising:

a server;

a memory in which cells of the connections are stored, said memory connected to the server; and

a scheduler having a schedule bitmap which is either statically stored or dynamically generated which schedules when cells of the connections in the memory are to receive service from the server, said scheduler connected to said server.

35. An apparatus for serving connections comprising:

a server;

a memory in which cells of the connections are stored, said memory connected to the server; and

a scheduler which maintains active bitmaps which indicate which connections are active which schedules when cells of the

connections in the memory are to receive service from the server, said scheduler connected to said server.

36. An apparatus for serving connections comprising:

a server;

a memory in which cells of the connections are stored, said memory connected to the server; and

a scheduler having a schedule bitmap and active bitmaps which indicate which connections are active, the scheduler filters out inactive connections from the schedule bitmap by ANDing schedule bitmap with the active bitmaps, the scheduler schedules when cells of the connections in the memory are to receive service from the server, said scheduler connected to said server.

37. An apparatus for serving connections comprising:

a server;

a memory in which cells of the connections are stored, said memory connected to the server; and

a scheduler having schedule bitmaps which can contain multiple bits per connection to schedule different types of bandwidth, the scheduler schedules when cells of the connections in the memory are to receive service from the server, said scheduler connected to said server.

38. An apparatus for serving connections comprising:

a server;

a memory in which cells of the connections are stored, said memory connected to the server; and

a hierarchical scheduler having levels of hierarchy, the scheduler can enforce rate limiting at each level of the hierarchy, the scheduler schedules when cells of the connections in the memory are to receive service from the server, said scheduler connected to said server.

2025 RELEASE UNDER E.O. 14176